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Economics of Swine Selection Programs that Improve Efficiency of Commercial Swine Production

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If the swine industry is to prosper in the United States, disciplined, well-planned efforts must be taken to improve production efficiency. Poultry, which is pork's major competitor in the market place, has made rapid genetic improvement resulting in more efficient production. Genetic selection has more than doubled eight-week weight of broilers (Table 1) and improved feed efficiency so that most broilers produce one pound of live weight gain for every 2.0 to 2.15 pounds of feed.

Because of genetic selection for growth rate, feed conversion, and dressing percent, broilers require only one-third as much feed per pound of retail product as pork (Table 2). More efficient poultry production has resulted in relatively low poultry prices which has shifted consumer demand. From 1963 to 1983, per capita consumption of poultry (chicken and turkey) increased by 70 percent (37.5 to 63.4 lb.) while pork consumption declined 11.5 percent (63.3 to 56.0 lb.).

The most alarming statistic is the sizable decrease in the number of swine producers in the U.S. In 1979 there were 700,000 swine producers and in 1984 there were only 450,000 producers. This is equal to a loss of 9.2 percent or about one out of every eleven producers each year. Pork production's slower rate of improved efficiency as compared to poultry production is primarily responsible for this decline.

Table 1. Eight-week weight (lb.) as affected by changes in feed and genetic selection.

Genotype (year)	Feed 1953	Feed 1976	Average
	---------- pounds ----------		
1958	1.99	2.10	2.04
1976	4.18	4.43	4.30
Average	3.08	3.26	

To compete with poultry and other alternative sources of protein, the swine industry must become more efficient as measured by the cost of producing a pound of quality retail product. Improvements in efficiency must occur in all areas of swine production: nutrition, management, health, and genetics.

Improved Efficiency Through Genetics

Genetic selection is responsible for most of the improvement in both growth rate and feed efficiency of poultry (Table 1). The swine industry has not had the leadership for, nor commitment to, performance testing and selection necessary for any consistent genetic change to occur. The swine industry has been filled with many ideas about how genetic progress can be made, but comprehensive genetic improvement programs have not been widely implemented. Comprehensive genetic improvement programs must include three features:

1. **accurate, complete performance records** including accurate animal identification, consistent measurement of all available observations (not on-again, off-again, or single boar performance testing), and precise definition of contemporary groups (animals of the same breed and sex which have had an equal opportunity to express their genetic potential);

Table 2. Feed required per pound of retail product.

Item	Poultry	Swine
Lb. feed to lb. grain growing-finishing	2.0	3.4
Retail product as a % of live weight	73.0	41.0
Lb. feed/lb. retail product	2.74	8.29

2. **assessment of the genetic merit** of economically important traits (growth, feed efficiency, carcass merit, and reproductive performance) of the individual hog's performance, and the performance of relatives; and

3. **indexes weighting traits** relative to their economic importance in commercial swine production. (The indexes should correctly rank the swine relative to their intended use in crossbreeding systems.)

An example of a comprehensive swine selection program is discussed in AS-435, "The Purdue Swine Improvement Program." The current estimated breeding value (EBV) program involves four basic traits: (1) number born alive, (2) 21-day litter weight, (3) days to 230 pounds, and (4) backfat thickness. Three indexes, maternal, terminal sire, and general-rotation, weight the EBV's relative to their economic importance in commercial crossbreeding systems.

More complete EBV programs will be developed in the future. The programs will likely allow seedstock producers to include other optional traits such as age at first farrowing, average daily gain, rebreeding interval, pen or individual feed efficiency, and carcass data. The computer programs will likely allow the calculation of across-herd sire evaluations, a necessary step for identifying the superior individuals within a breed.

Performance Records Must Be Kept Within the Seedstock Herds

To gain long-term genetic progress for any economic trait, performance data must be collected and superior animals selected to reproduce the next generation. It is vital that this selection occur within seedstock herds. Figure 1 shows the expected increase in genetic merit for any trait when records are kept and superior gilts are selected within commercial herds while the boars purchased from seedstock herds are not improving. The first three to four generations will result in a small amount of genetic progress. However, after six generations no appreciable improvement is possible because the unimproved boars introduced into each generation constantly cancel out any gains made by gilt selection. Response to selection will soon plateau and from that time on, the commercial producer can select the superior gilts within the herd without any improvement in the genetic merit of his herd.

It is also important to realize that gilt selection is not additive within the commercial herds, does not accumulate, and must be continued or any small gains realized will suddenly disappear. If the commercial gilt selection is discontinued at any time, the genetic merit of the commercial herd will decline to the unimproved level of seedstock herds.

To make long-term genetic progress for any economically important trait (number born alive, 21-day litter weight, growth rate, feed conversion, or backfat thickness), performance records must be kept and superior animals selected within the seedstock herds. Also, it is less expensive for records to be kept within the smaller and less numerous seedstock herds in comparison to commercial swine herds. For example, a seedstock producer farrowing 200 litters and selling 200 boars per year would need to performance test about 1,600 animals per year (8 pigs per litter). With 500 commercial hogs produced per boar sold, the seedstock producer would control the genetic merit of 100,000 commercial offspring per year. Gilt selection within commercial herds would require 50,000 gilts to be performance tested annually.

Figure 2 shows the expected increase in genetic merit if the seedstock herds are making genetic progress. The genetic merit of commercial herds parallels the genetic progress made by

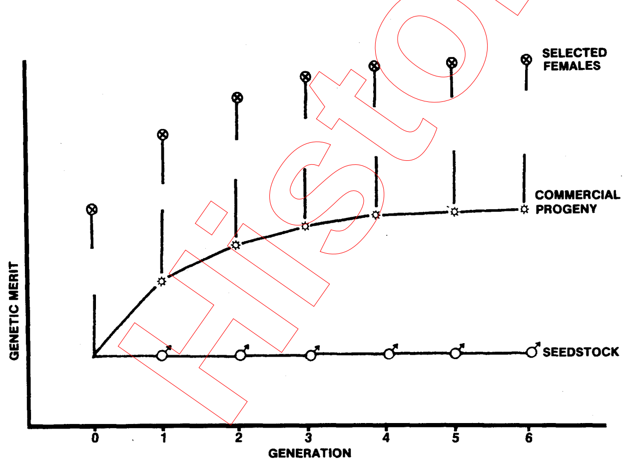

Figure 1. Expected genetic improvement of commercial swine herds without seedstock herd improvement.

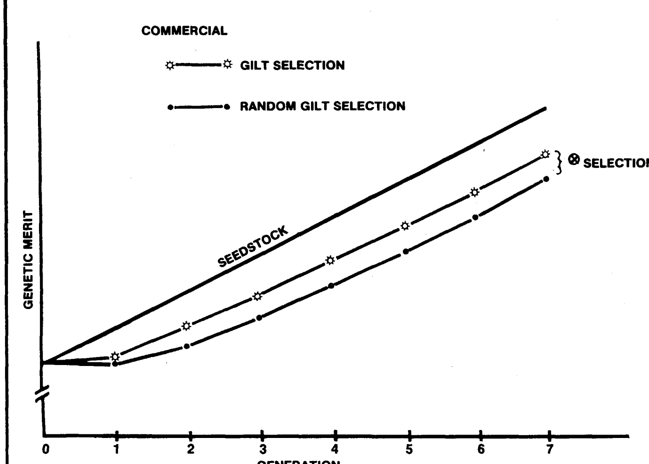

Figure 2. Expected genetic improvement of commercial swine herds with or without gilt selection as seedstock herds.

seedstock herds. In this situation, commercial gilt selection will enable commercial herds to approach the genetic level of seedstock herds.

For seedstock herds to make consistent genetic progress as presented in Figure 2, they must use a high percentage of superior performance tested boars either from their own herd or from other herds with sound performance testing and selection programs.

Figure 3 shows the expected increase in genetic merit in herds using differing percentages of superior performance tested boars. If the seedstock producer selects his own replacement gilts but purchases boars without performance records and/or from herds without performance testing and genetic selection programs, little genetic progress is possible. If the seedstock producer uses only 25-50 percent superior performance tested boars, little genetic progress is possible. By compromising his selection program and using untested boars and/or boars from producers who have not selected superior boars themselves, genetic progress is reduced after three to five generations.

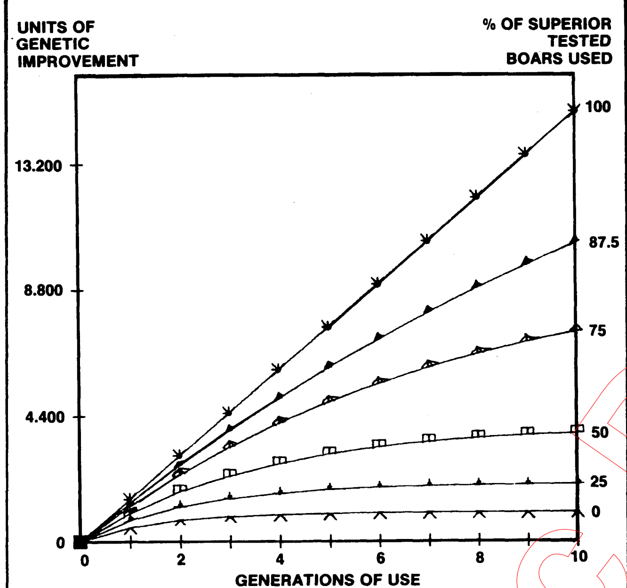

*Figure 3. Expected increase in genetic merit with different percentage superior performance tested boars used.**

*A superior performance tested boar is one in the upper 6 percent of those tested from either the producer's own herd or from other herds with sound performance testing and selection programs including exclusive use of superior tested sires. It is assumed that the seedstock producer is selecting the replacement gilts ranking in the upper third of those tested on his own farm.

As herds implement sound genetic programs and increase in genetic merit, the probability increases that untested boars or boars from unimproved herds will reduce the herd's genetic merit. As the percentage of superior performance tested sires increases, the amount of genetic progress realized after 10 generations increases. A commercial producer cannot expect the genetic merit of his seedstock producer's herd nor the performance level of his own animals to consistently improve unless the seedstock producer uses superior performance tested boars. Therefore, commercial producers should purchase seedstock from those producers who have a performance test data available on boars for sale and almost exclusively use superior performance tested sires.

Sow Productivity Indexing and Sow Culling

Although it is clear that genetic selection must occur within seedstock herds, many swine management specialists have recommended that commercial producers collect farrowing and litter weight data to rank their sows on a sow productivity index (SPI). The reasoning behind this recommendation is that with SPI's, a producer can cull the lower-producing sows and increase the average performance of the sow herd. However, if one examines this recommendation in detail, it becomes obvious that sow culling, whether based on litter size, litter weight, or SPI will not improve the performance of a sow herd.

It is important to realize that first and second litter (parity) sows do not perform as well as mature sows (Table 3). To maintain optimal herd performance, it is necessary to maintain a balance between the various priorities. A replacement program with 20-28 percent first litter gilts will result in maximum sow herd performance.

Average sow performance with voluntary culling (the discarding of lower-performing sows based either on litter size or SPI) procedures is compared

Table 3. Changes in litter size (number born alive) and sow productivity index (SPI*) with parity.

	Parity					
	1	2	3	4	5	6 or more
Litter size†	86	93	100	100	102	100
SPI‡	-16.4	-5.4	0	0	0	-7.00

* SPI = 6.5 (number born alive) + 1.0 (adjusted 21-day litter weight).

† Expressed as a percent of fourth parity sows.

‡ Expressed as a deviation from fourth parity sows.

to involuntary sow culling (death, lameness, old age, abortion, farrowing difficulties, etc.) in Table 4. If voluntary sow culling regimes such as A through D are based on litter size, an improvement of only .04 pigs per litter can be expected. If culling is based on a SPI, the producer can expect his sow herd to improve by about one SPI index point. This one index point improvement would be caused by a .08 pig increase in number born alive and .5 pound increase in litter weight. Voluntary sow culling will increase the observed performance of the remaining older sows. However, each sow culled (either approaching or currently expressing her top lifetime performance) must be replaced by a lower-performing first litter gilt. Sow culling procedures result in little improvement in overall herd performance because of the resulting increase in percentage of lower-performing first and second parity sows.

Table 4. Percentages of sows of different ages under various voluntary culling procedures.

Parity	With no voluntary culling	Voluntary culling regime* A	B	C	D
1	18	23	33	22	22
2	16	15	12	19	18
3	14	13	11	12	14
4	12	11	10	11	12
5	11	10	9	9	10
6 or more	29	28	25	27	24
Average litter size†	10.60	10.66	10.63	10.66	10.60
SPI‡	144.1	145.2	145.0	145.5	145.6

* A = culling poorest 25 percent after 1 litter
B = culling poorest 50 percent after 1 litter
C = culling poorest 25 percent after 2 litters
D = culling poorest 5 percent based upon all sow's records

† 11 = mean of fourth parity sows, selection criteria is number born alive

‡ 150 = mean SPI of fourth parity sows with no voluntary culling, selection criteria is SPI.

Commercial producers should record sow productivity data as a means to monitor and evaluate herd production. Measurements such as number born alive, number weaned, percent death loss from birth to weaning, and pigs weaned per sow per year can be used as management tools to improve production efficiency. If such records are being collected, producers can use their records as a basis of sow culling but no large or continued improvement in herd performance should be expected as a result of such sow culling procedures alone.

Economic Returns of Selection Within Seedstock Herds

Genetic progress within seedstock herds is additive and accumulates from one generation to the next when uniform selection criteria are used. It has been estimated that selection based on the rotational EBV index (I = 100 + 15.4 EBV for litter size + .80 EBV for litter weight - 1.56 EBV for days to 230 pounds - 29.5 EBV for backfat depth) of the Purdue Swine Improvement Program would result in an annual improvement in profit potential of $1.88 per hog. When selection is based on a combination of soundness, underlines, and index values, then the expected annual improvement in profit potential is $.94 per hog. This figure may not seem significant. However, keep in mind that annual improvement accumulates within seedstock herds and is multiplied to many commercial pigs.

Table 5 shows the expected genetic merit of seedstock and commercial herds measured as profit difference when the selection occurring within a seedstock herd is based on the rotational EBV index. The annual rate of genetic progress expected is $.94 per hog for the first 10 years (6.7 generations). This rate of expected genetic progress is only one-half that expected if selection is based totally on the index. After 10 years of genetic selection, the hogs produced would be expected to have the following traits:

1. .12 inch less backfat,
2. .24 less feed per pound gain,
3. 12 days sooner reaching market weight, and have
4. .8 pig plus 7-pound heavier litters than unselected animals.

The annual rate of genetic progress is expected to decrease between years 10 and 15 to approximately $.60 per hog. By the end of 15 years of selection on the rotational EBV index, the hogs produced would display the following traits:

1. .16 inch less backfat,
2. .32 better feed conversion,
3. 15.2 days sooner to reach market weight, and have
4. 1 pig plus 9.2 pound heavier litters than unselected animals.

The improved genetic merit of boars purchased from seedstock herds will improve the profit potential for pork producers. The genetic merit of commercial herds will parallel the genetic improvement within seedstock herds (Table 5 and Figure 2). Assuming the seedstock producer sells 200 boars per year each having 500 commercial offspring (100,000 total offspring), the accumulative value of the selection program to commercial pork producers is substantial. After 10 years, the increase in profit to commercial pork producers is $3.1 million. After 15 years, the value of a disciplined selection program measured as the increased profitability of the commercial producer hogs is approximately $7.8 million. About 85 million hogs are produced in the U.S. per year, 850 times more than the 100,000 commercial hogs used in the example. Commercial swine producers will become more

Table 5. Profit potential for commercial producers when selection occurs within seedstock herds.

Year	Seedstock herd levels* value at the start and end of each year	Average	Commercial herd level†	Dollar value‡
0	0	0.0	0.00	0
1	0.00 - 0.94	.47	0.00	0
2	0.94 - 0.88	1.41	.235	23,500
3	1.88 - 2.82	2.35	.822	82,200
4	2.82 - 3.76	3.29	1.58	158,000
5	3.76 - 4.70	4.23	2.44	244,000
6	4.70 - 5.64	5.17	3.33	333,000
7	5.64 - 6.58	6.11	4.25	425,000
8	6.58 - 7.52	7.05	5.18	518,000
9	7.52 - 8.46	7.99	6.11	611,000
10	8.46 - 9.40	8.93	7.05	705,000
			accumulative subtotal for years 0-10 =	$3,099,700
11	9.40 - 10.00	9.70	7.99	799,000
12	10.00 - 10.60	10.30	8.84	884,000
13	10.60 - 11.20	10.90	9.57	957,000
14	11.20 - 11.80	11.50	10.24	1,024,000
15	11.80 - 12.40	12.10	10.87	1,087,000
			accumulative total for years 0-15 =	$7,850,700

* The seedstock herd improves at annual rate of $.94 from years 1 to 10 and $.60 from years 11 to 15. These values are approximately one-half of that expected if selection was based totally on the index.

† The commercial herd profit difference per hog is equal to the average genetic level of the boars purchased and home-raised replacement gilts from the previous year.

‡ Value of the seedstock producer's genetic selection program in improving the profit potential of commercial hogs produced by his boar purchasers each year. This value assumes that the seedstock producer sells 200 boars per year with 500 offspring per boar (100,000 total offspring per year).

efficient and potentially more profitable when sound genetic programs are implemented within seedstock herds.

Economic Returns of Selection Within Commercial Herds

Commercial producers managing terminal crossbreeding systems are acting as their own seedstock multiplier of replacement gilts, either F_1 gilts in a specific crossbreeding system or rotational-cross females in a rotaterminal crossbreeding system. It seems logical that perhaps by mating the higher indexing sows to produce replacement gilts, a small amount of genetic progress can be made. Let's examine the expected amount of genetic progress and economic returns.

For the specific crossbreeding system, assume that the matings are in the percentages presented in Figure 4. In this example, one-fourth (5 of the 20%) of the Yorkshire sows are mated to purebred Yorkshire boars to produce purebred replacement gilts. Assume that 45 percent of the Yorkshire herd are first and second parity sows which are all mated to produce crossbred litters. Assume the producer selects the top Yorkshire sows (25% of the Yorkshire herd, 5% of the total herd) from the sows with two or more litters (55% of the Yorkshire herd) based on the sow productivity breeding value index (I = 100 + 16.1 EBV for litter size + 1.0 EBV for litter weight). Also assume that the average

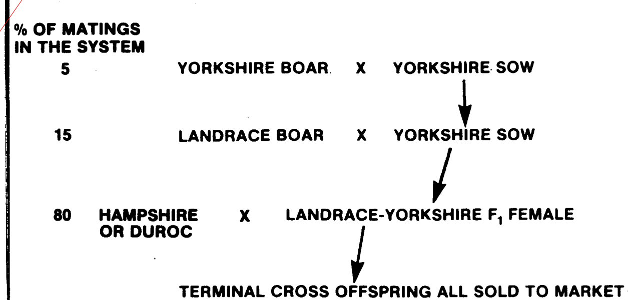

Figure 4. An example of a specific cross.

accuracy is .48 for litter size and .63 for litter weight, approximately equal to each sow having 2 records, 2 full-sibs, and 12 half-sibs with an average of 1.5 records each. The expected genetic progress in the sows is .366 for litter size and 2.97 pounds for litter weight. The purebred replacement gilts, which comprise 20 percent (5% purebred and 15% crossbred matings) of the total herd farrowings will receive one-half of the genetic progress (.183 for litter size and 1.48 lb. litter weight). The F_1 gilts produced the following generation, comprising 80 percent of the total herd, will only receive one-fourth the genetic progress (.092 for litter size and .74 lb. litter weight).

The weighted average improvement of the producer's sow herd is .11 pigs born alive and .89

pounds litter weight. The value of this improvement is $4.49 per sow farrowed. By taking records and selecting the top Yorkshire sows, which comprise 20 percent of the total herd, the resulting replacement purebred and F_1 gilts will have an average advantage of $4.49 as compared to no selection. Producers operating specific crossbreeding systems must ask themselves, "Is the expense of collecting the litter size and litter weight data, identifying the sire and dam of each Yorkshire sow, having the EBV's calculated, and making the selection worth $4.49 per litter farrowed"?

Large commercial producers who have their own purebred Landrace and produce their own Landrace boars can make additional progress. However, unless the number of purebred Landrace females is over 30, the amount of genetic progress will be small because a high percent of the replacement sires will need to come from outside sources to reduce inbreeding.

For the rotaterminal crossbreeding system, assume that the matings are made according to the percentages presented in Figure 5. Assume that first and second parity sows are mated to produce terminal cross market hogs and comprise 45 percent of the total herd.

Assume that the producer selects the top indexing sows (14% of the total sow herd) from the sows which have already had two or more litters (55% of the total herd) based on the sow productivity breeding value index. Assume that the average accuracy is .48 for litter size and .63 for litter weight. The expected genetic progress for the sows, assuming the same records as the past example, will be .514 pigs born alive and 4.18 pounds litter weight. The replacement gilts will receive one-half of this genetic progress (.257 pigs born alive and 2.09 lb. litter weight). The value of this selection is $10.51 per litter farrowed. This $10.51 return per litter requires that litter size and litter weight data be collected for each sow, each sow's sire and dam will be identified, the EBV's calculated and selection be made. Compare this to the specific crossbreeding system in which the returns are smaller ($4.49 per litter farrowed) but fewer records (only for the Yorkshire sows which comprise 20% of the herd) are required.

Summary

Accelerated genetic improvement will lead to more efficient swine production and improve pork's competitiveness with other protein sources. Comprehensive selection programs are available and must be used by seedstock producers if consistent genetic progress is to be achieved. Genetic progress within the seedstock herds is additive and can greatly affect the efficiency of commercial swine production. It is for this reason that commercial producers must purchase their seedstock from suppliers with sound genetic improvement programs including the use of superior performance tested boars.

Commercial producers should inquire about their seedstock producer's performance testing and selection programs. The selection programs should emphasize the genetic improvement of economically important traits. The traits should be weighted relative to the seedstock's intended use in commercial crossbreeding systems.

Commercial producers should be willing to pay a premium for genetically improved seedstock, not only because of their increased value to the individual commercial producer and the swine industry, but also to offset the seedstock producer's performance testing costs. The support of seedstock producers with comprehensive genetic improvement programs, including the use of superior performance tested sires, is necessary to guarantee their existence which in turn will lead to more efficient commercial swine production.

Related Publications

For more information on swine selection programs and EBV's, contact your county Extension office or write the Publications Mailing Room, 301 South Second Street, Lafayette, IN 47905-1092, for the following publications:

AS-435 The Purdue Swine Improvement Program
AS-436 Using Estimated Breeding Values for Swine Improvement

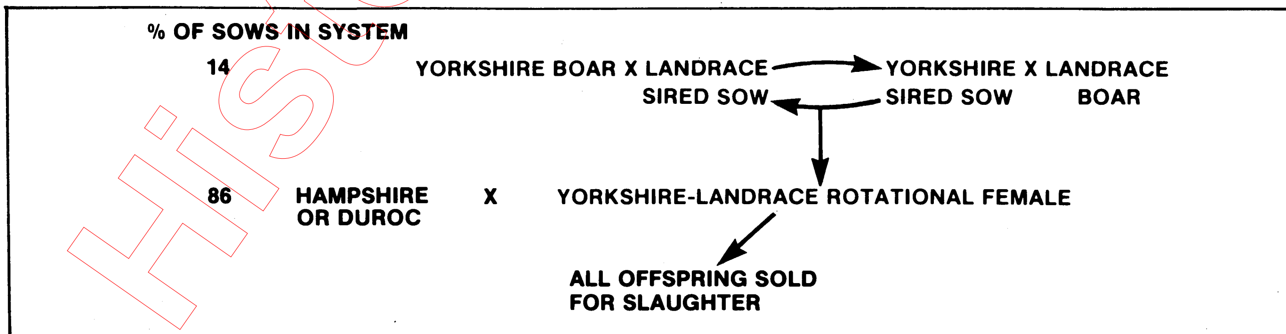

Figure 5. Example of rotaterminal crossbreeding system.

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